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August 1978

THE 1977 TUNDRA FIRE AT KOKOLIK RIVER, ALASKA

D. Hall, J. Brown and L. Johnson

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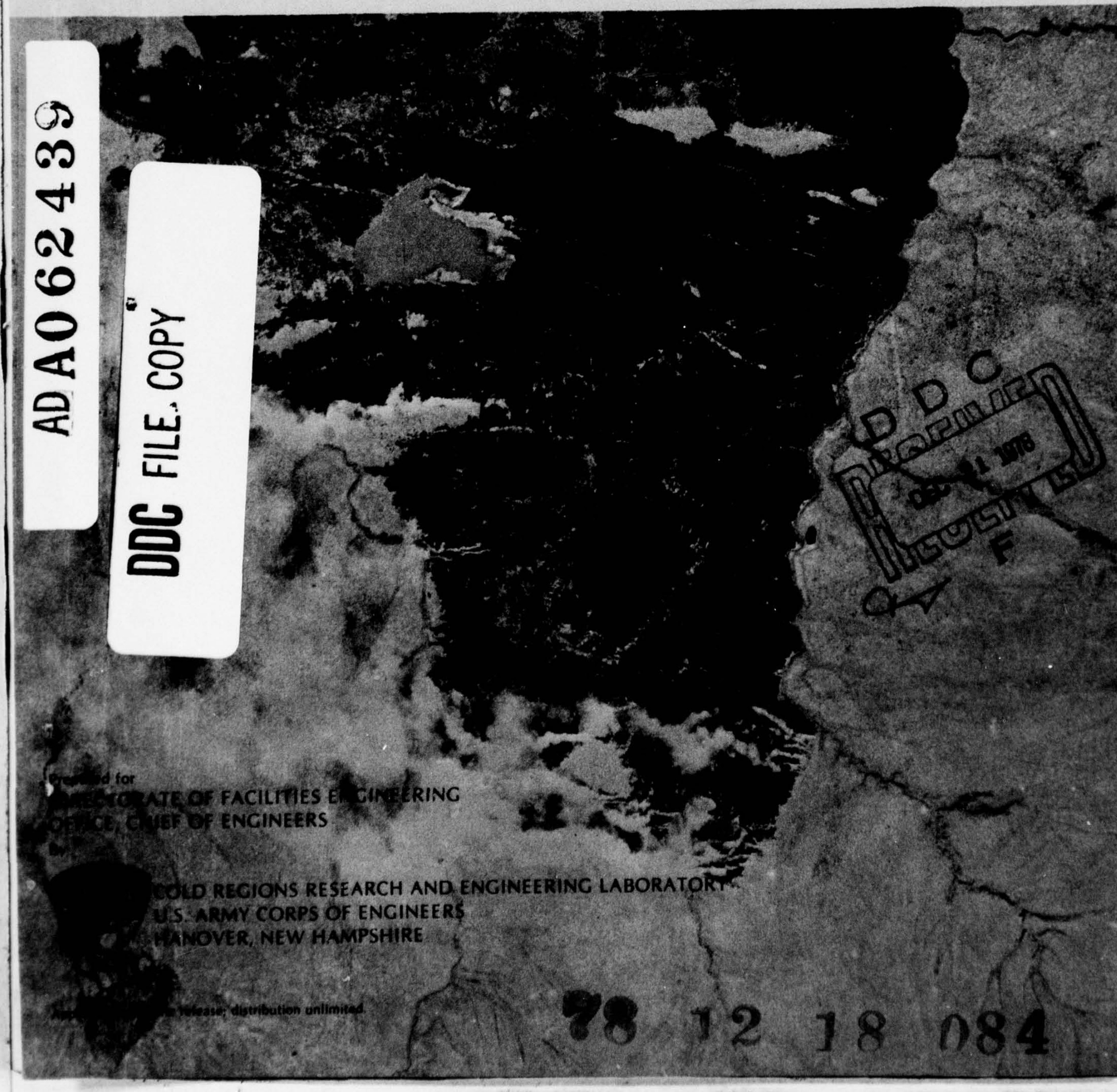

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Cover: Aerial photograph of southern portion of Kokolik fire obtained by NASA Johnson Space Center, Mission 364, 1 August 1977. Note smoke plumes with wind blowing from the east.

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During summer 1977 widespread fires occurred in northwest Alaska. Through the use of Landsat imagery and ground studies, one such fire, at Kokolik River, was examined. The Kokolik fire was first reported on 26 July, and by the time it was extinguished had consumed 44 km^2 of tundra vegetation. Streams and drainages contained the fire on several sides. Ground observations provided information on the intensity of the fire effects. Depth of thaw by late August measured 35.4 cm in the burned areas and 26.6 cm in the unburned areas.

44 sq km

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PREFACE

This report was prepared by D. Hall, Research Geographer, NASA/Goddard Space Flight Center; and J. Brown, Research Soil Scientist, Earth Sciences Branch, and L. Johnson, Research Biologist, Alaskan Projects Office, U.S. Army Cold Regions Research and Engineering Laboratory.

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THE 1977 TUNDRA FIRE AT KOKOLIK RIVER, ALASKA

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INTRODUCTION

Widespread fires occurred on the Seward Peninsula during the summer of 1977. During this period there was also one large natural fire in northern Alaska. This fire occurred due east of Pt. Lay and several kilometers southwest of the Kokolik River, Alaska (69°30'N, 161°50'W; Fig. 1). No tundra fires have previously been reported from this area. However, fires on the North Slope during the years 1969 to 1971 were reported, four of which were reportedly caused by lightning (Wein 1977, Barney and Comiskey 1973). According to the Bureau of Land Management (BLM) smoke jumper records, this was the northern-most fire ever manned by BLM in Alaska.

The fire, presumably caused by lightning, occurred on the boundary between the coastal plain and the northern foothills (McCulloch 1967). It apparently started just west of the National Petroleum Reserve — Alaska (NPRA) boundary and spread eastward into the NPRA (Fig. 1).

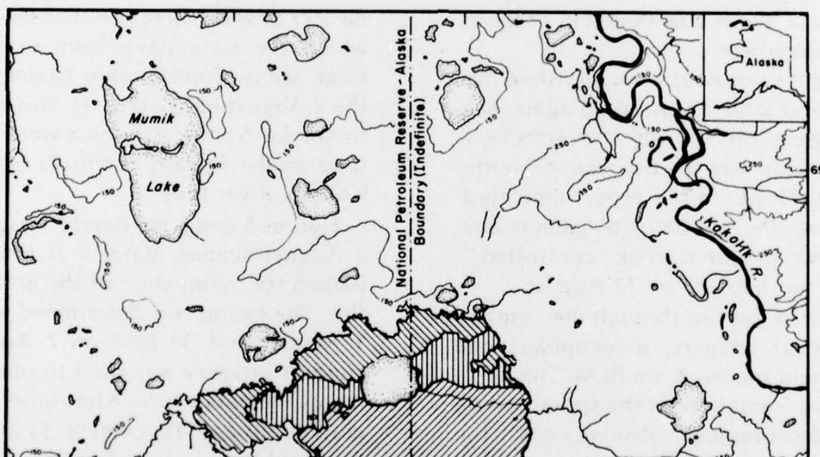

Figure 1. Location map of Kokolik River tundra fire with 1, 2, and 27 August boundaries of the fire. Boundaries of the fire were drawn from 1:63,360 Landsat photographic enlargements prepared by T. Marlar, CRREL.

Climatic conditions in northern and western Alaska during the summer of 1977 were apparently ideal for tundra fires. Cape Lisburne, operated by the U.S. Air Force, is 185 km to the southwest on the coast and is the closest available reporting station to the 1977 Kokolik River fire.

July was extremely dry (5.3-mm rainfall) and average temperatures were above normal. Maximum air temperatures in late July were in the mid-teens and low 20s (°C). In general, the North Slope experienced an extremely dry July with no precipitation reported from Umiat or Barrow for the period 9 to 24 July 1977.

The fire was discovered by the BLM on 26 July, at which time its extent was estimated at 0.4 km². But high winds prevented the firefighters from landing on 26 July. These winds, which continued through 31 July, undoubtedly contributed to the intense nature of the fire. By noon on 27 July, when the first BLM firefighters arrived, the extent was estimated at 4.0 km². BLM personnel fought the fire from 27 July to 31 July, at which time it was abandoned in order to deal with fires elsewhere.

Apparently light rains nearly extinguished the fire on 28 July, and after it started up again, fog slowed its progress on 30 July. Nevertheless, Landsat imagery indicates the fire was still burning on 2 August. The BLM fire report indicated that on 7 August the fire had not gained any "acreage" and was declared to be "controlled." It was declared out by BLM on 12 August.

We have studied the fire through the combined use of Landsat imagery, a reconnaissance field trip, and field reports from BLM. This short report presents information on the spread of the fire, the meteorological observations, the natural containment of the fire, and the ground investigations following the fire.

SATELLITE OBSERVATIONS

Landsat multispectral scanner subsystem (MSS) imagery has previously been employed to measure the progression and areal extent of wildfires (Haugen et al. 1972). Landsat provides repetitive coverage with a spatial resolution of 80 m. The MSS onboard the Landsat-1 and -2 satellites provides imagery in four spectral bands; band 4 (0.5-0.6 μm) and band 5 (0.6-0.7 μm) in the visible range; and band 6 (0.7-0.8 μm) and band 7 (0.8-1.1 μm) in the near-infrared range. Only imagery from bands 5 and 7 was used in this study. Analysis of the 1977 Landsat imagery provided considerable information on the areal extent and movement of the Kokolik River fire, as well as the rapidly changing wind conditions which affected the spread of the fire.

Figure 2 shows the area of the Kokolik River fire before the fire on 21 July 1977. Note the two small lakes southest of Mumik Lake. These lakes became surrounded by fire as seen on later Landsat scenes.

By 1 August the fire was burning quite intensively (Fig. 3). The smoke shows up clearly on band 5 imagery and provides a good indicator of wind direction. On 2 August a drastic shift in wind direction from the previous day occurred, as seen in Figure 4. National Weather Service Synoptic Maps indicate that there was a shift in the wind direction from northeast at 5 knots on 1 August to southwest at 10 knots on 2 August (NWS 1977). This information correlates well with the information derived from Landsat. In fact, the Landsat imagery is probably a better indicator of wind direction than the NWS maps for which the data have been extrapolated over large areas. Considerable haziness is visible on the 2 August image (Fig. 4). This is probably due to smoke from fires which were burning at the time on the Seward Peninsula (southwest of the Kokolik River fire).

Figures 5 and 6 are band 7 images of the 1 and 2 August scenes. Band 7 is more useful than band 5 for delineation of the areal extent of the fire. The extent was determined to be 26 km² on 1 August and 34 km² on 2 August. Digitized Landsat imagery was used to obtain these areal measurements on the Atmospheric and Oceanographic Image Processing System (AOIPS) at Goddard Space Flight Center.

Black and white positive transparencies of Landsat scenes were scanned and projected onto a television screen. The burned area was then delineated by a cursor.* Subsequently, a pixel (picture element) count of the burned area was taken. The number of Landsat pixels was determined and then the total extent in square kilometers was calculated. Digital analysis of the 1 and 2 August images revealed an 8-km² increase in extent of burn over the 24-hour period. Measurements using a 21 August image (Fig. 7) revealed an ultimate extent of 44 km² for the burn. No Landsat images could be obtained between 2 and 21 August but the fire was considered to be out by 12 August.

*The cursor on a computer terminal delineates the outline of the burned area.

Figure 2. Landsat image of Kokolik River area, before fire, 16 July 1977, scene 2906-21410, band 7.

Figure 3. Landsat image of Kokolik River fire in progress showing smoke plumes, 1 August 1977, scene 2922-21284, band 5.

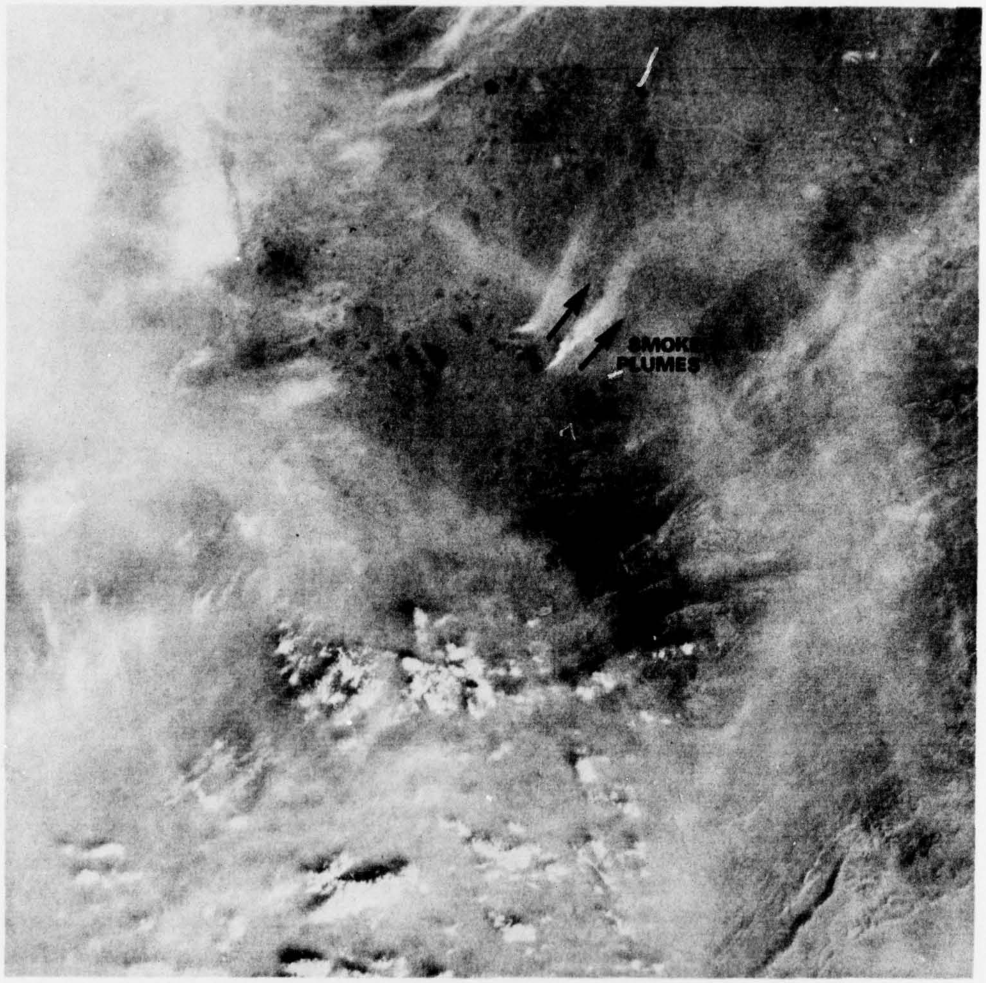

Figure 4. Landsat image of Kokolik River fire in progress showing smoke plumes, 2 August 1977, scene 2923-21342, band 5.

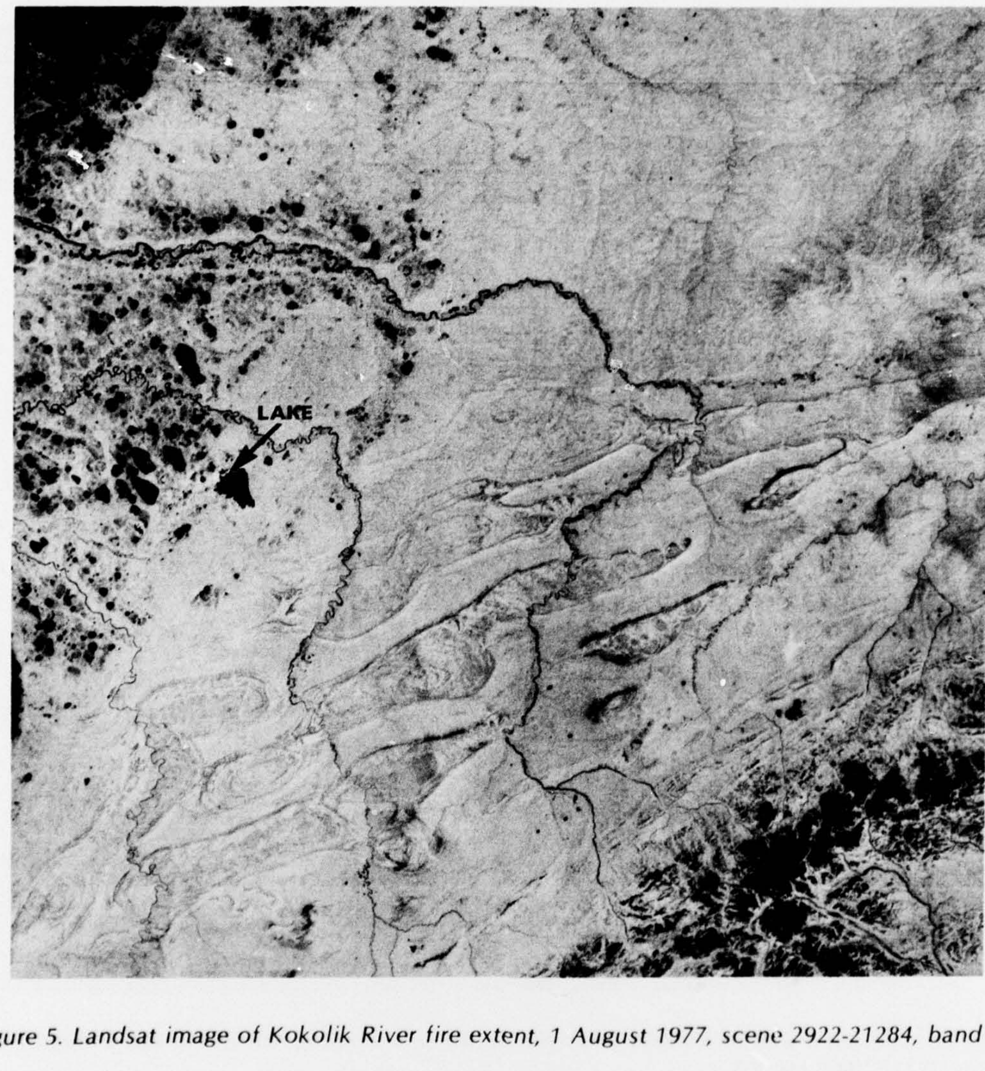

Figure 5. Landsat image of Kokolik River fire extent, 1 August 1977, scene 2922-21284, band 7.

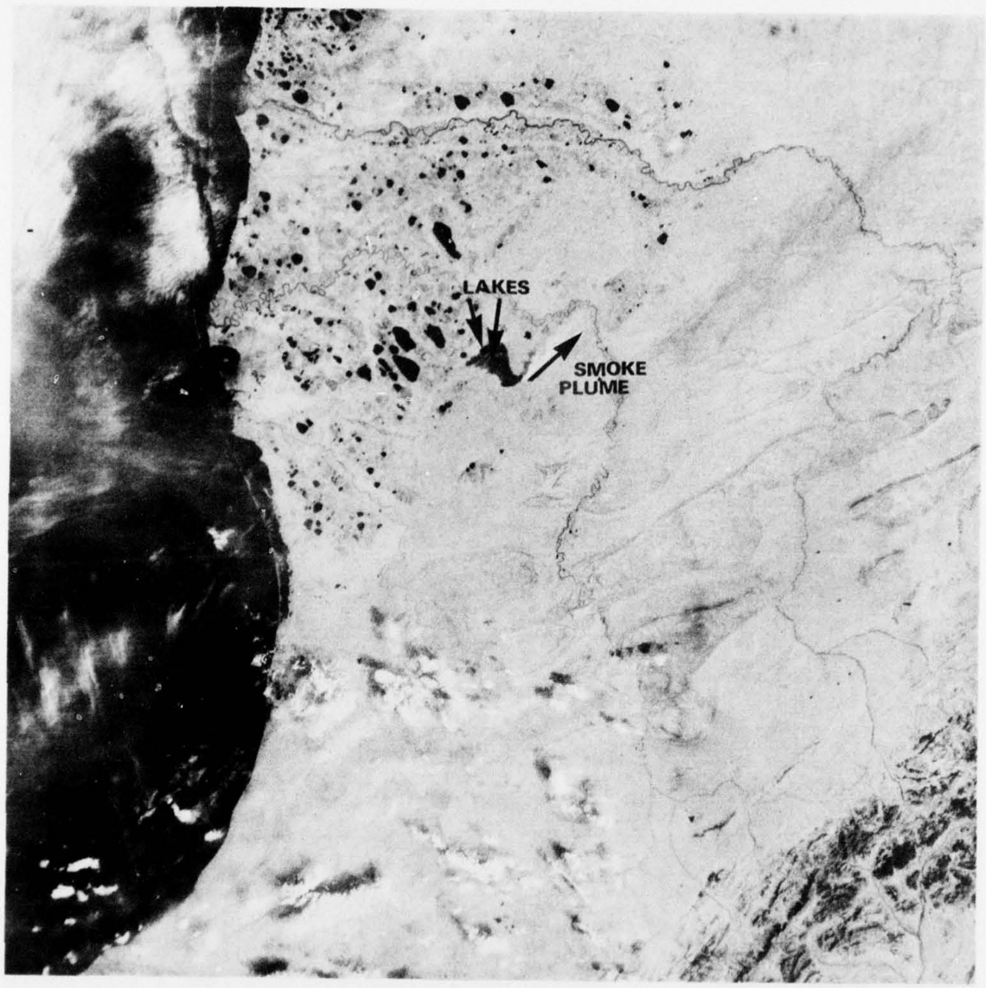

Figure 6. Landsat image of Kokolik River fire extent, 2 August 1977, scene 2923-21342, band 7.

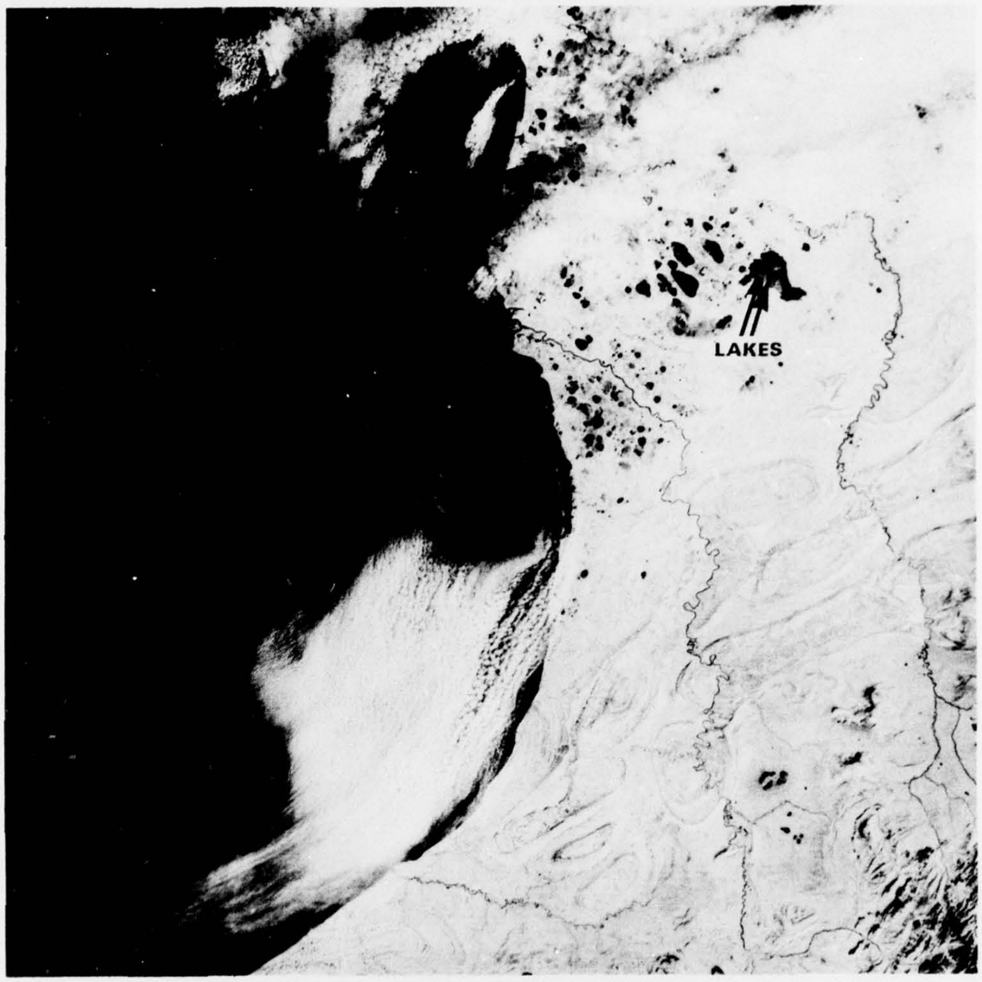

Figure 7. Landsat image showing maximum extent of Kokolik River fire, 21 August 1977, scene 2942-21390, band 7.

Figure 8 shows 1:250,000-scale enlargements of the Kokolik River burned area on 1 and 27 August 1977. By superimposing the burned areas from the Landsat imagery on the 1:250,000 Pt. Lay and Utukok River U.S. Geologic Survey topographic maps, it became apparent that the stream bordering the fire on the east formed a natural fire barrier. The fire then spread northward and southward (Fig. 1) being arrested again by streams to the north. The small streams that ultimately contained the fire are below the 80-m resolution of the Landsat imagery. However, recently available NASA aerial photography, obtained on 1 August 1977 (see cover photograph), confirms the fact that the streams contained the fire, as interpreted on the Landsat imagery.

GROUND OBSERVATIONS

Craig Johnson of the Forest Soil Laboratory, University of Alaska, and Lawrence Johnson, CRREL, spent 30 August on site after landing there by a BLM-chartered helicopter. Low-altitude observations from the helicopter indicated that that fire burned a range of vegetation and relief types which included low polygonized and upland tussock tundras. The fire was extremely hot and, although exposed mineral soils in the upland tundra were not a high percentage of the total area, the extent of bare soils was several times greater in the burned areas than in comparable unburned areas. Some of the bare areas could have been exposed previously as frost scars or boils.

A transect within the upland tundra was established from approximately 180 m within the burn, to the edge of the burn, across a small creek and up onto the unburned tundra. The exact ground location of the transect was difficult to ascertain because of poor visibility from the air, but was most likely located on the eastern edge of the burn (Fig. 1). Three 1-m²

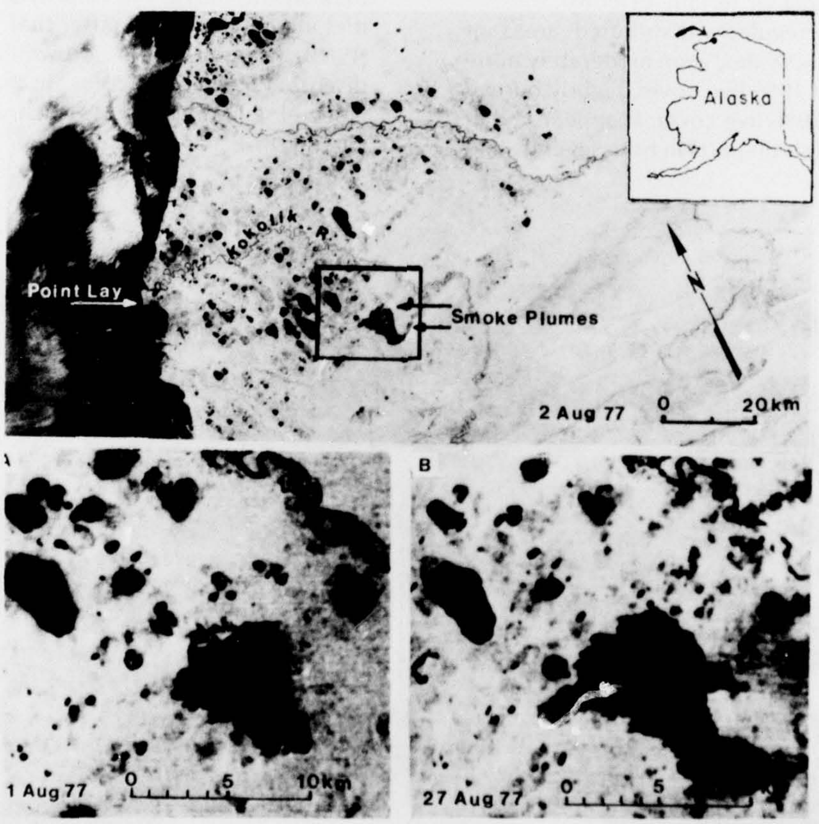

Figure 8. Landsat band 7 scene (2923-21342) of Kokolik River fire, showing extent and direction of smoke on 2 August 1977. Insert shows a 1:250,000 scale enlargement of the fire area from (A) 1 August (2922-21284 and (B) 27 August (5861-20500) scenes.

quadrats were established in each of the following burned areas: 1) severely burned tussock tundra, 2) moderately burned wet tundra, 3) lightly burned shrub tundra at the edge of the fire, and 4) unburned tussock tundra. Percentages of cover of live vascular plants, mosses, lichens, and charred surface were observed within each quadrat. Soil samples were obtained for subsequent nutrient analysis. Depth of thaw was measured at five points within the quadrat and at 25-m intervals along the 180-m transect.

By comparison with the unburned vegetation, which had large, well-developed tussocks, it was estimated that 80-90% of the biomass of the tussocks was consumed in the fire. All areas of raised relief, which characteristically consisted of tussock tundra, were severely burned and averaged less than 10% live cover. This may have been due to greater available fuel (litter and standing dead vegetation), drier soils associated with higher terrain, or both.

In contrast, irregularly distributed areas of low relief, such as swales, were moderately burned and averaged 10% live cover. Lightly burned areas averaged 50% live cover. It appeared that all aboveground shrub parts in both severely and moderately burned areas had been consumed by the fire, and if there were any living below ground parts, they had not sprouted by the end of August. In contrast, 80% of the tussocks already showed regrowth from shoots (Fig. 9). There was also regrowth in meadows containing *Carex* and *Eriophorum angustifolium* which occupy the low-lying, moderately burned areas. Similar late summer regrowth in tussocks was observed in the Elliott Highway tussock fire in 1969 (Wein and Bliss 1973, Brown and Vietor 1969).

The burned area appeared wetter on the surface than the unburned area because of a lack of moisture-absorbing organic matter and possible release of moisture from the deeper thawed zone. Depth of thaw between tussocks averaged 35.4 cm in the burned areas as compared with 26.6 cm in the unburned areas. Mackay (1977) reports upon the continued seasonal increase in thaw at the Inuvik fire following an average initial increase of 24 cm after that fire. Kriuchkov (1968) [translation in Brown et al., (1969)] discusses the initial increase in thaw followed by a decrease in subsequent years for tundra fires in Siberia.

Figure 9. Closeup of severely burned tussocks. Individual tussocks show regrowth. (Photograph by L. Johnson, CRREL, on 30 August 1977.)

CONCLUSIONS

The summer of 1977 Kokolik fire totaled 44 km^2 of tundra vegetation according to measurements using Landsat imagery. Based on the experience gained from analysis of this fire using ground observations, Landsat imagery, and topographic maps, it appears that natural drainages form effective fire breaks on the subdued relief of the arctic coastal plain and northern foothills. Furthermore, this study reconfirmed that intensity of the fire is related to vegetation type and moisture content of the organic rich soils.

FUTURE INVESTIGATIONS

The Kokolik River fire site provides an excellent site for continued investigations of fire effects on tundra and permafrost terrains. The following studies are desirable:

(1) Comparison of the nutrient runoff and change in primary productivity between the burned and unburned areas. The influence of both increased nutrient and sediment load on the lakes contained within the fire area (Fig.1) could also be followed.

(2) Monitoring depth of thaw changes and thermokarst development under burned areas of different intensity and moisture conditions. The hypothesis proposed by L. Viereck (personal communication) that intensity of frost action may be directly related to fire frequency on the Seward Peninsula could be tested at this site.

(3) Monitoring revegetation and successional changes on the burned areas. The increased flowering of *Eriophorum vaginatum* which normally occurs after a fire could provide a harvestable seed source for revegetation efforts elsewhere. Digital analyses of the available August 1977 Landsat imagery can be used to classify burn intensity as a function of reflectance differences.

(4) Acquisition of ground truth data, particularly on vegetation succession, which can be correlated with detailed digital analyses of future Landsat imagery. Landsat data obtained during the spring and summer of 1978 should reveal valuable information on initial vegetation response in the burned areas.

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